Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

DEC 24 19
LIBRARY
BUREAU OF AGRICULTURAL

ACE - 104

COOLING EGGS ON THE FARM AND AT GRADING STATIONS

(A Progress Report)

John W. Weaver, Jr., Reece L. Bryant and Cecil Rogers[1]

This paper covers in part experimental work on egg cooling conducted at the Virginia Polytechnic Institute and at several egg grading stations in the State of Virginia, mostly in the Roanoke area and in the Shenandoah Valley during the summer of 1940. Further tests are being conducted in the coastal regions where relative humidities are high during the summer months.

About eight hundred million eggs are produced annually on Virginia farms (11) and three fourths of these are sold, bringing in a cash income of nearly eleven million dollars a year to Virginia poultrymen. Fifty two percent of this annual production occurs during the five months* of warm and hot weather when eggs are selling for an average of three and one half cents less per dozen than during the remainder of the year. At the same time the poultryman is feeding young birds which produce almost no income before cold weather. The hot weather months then are the critical period for the poultryman and any method of increasing income during this time would prove most valuable.

Need for Quality

The annual production of eggs in Virginia has not increased appreciably during the past 10 years, but the average production per hen has increased a little over 13 percent since 1925. This unquestionably shows the results of new methods of feeding, breeding and management on the part of the poultryman. Yet when the eggs thus produced reach their ultimate market they apparently are lacking in the quality which is to be expected with good management. This lack of quality is indicated by the fact (1) that the average selling price of Virginia eggs is from one half to five and three fourths cents less per dozen than that received for eggs sold from the other seven states in the South Atlantic group.**

---

[1] Authors, respectively: Assoc. Agr. Engin., Bur. Agr. Chem. & Engin.,
U. S. Dept. of Agr.,
Asst. Poultry Husbandman, Va. Agr. Expt. Sta.,
Senior Supervisor, Div. of Markets, Va. Dept. of Agr.

(11) Numbers in parentheses refer to citations.

* May, June, July, August and September.

**Delaware, Maryland, West Virginia, North Carolina, South Carolina, Georgia, and Florida.

Feeling that the quality of eggs could be improved by better management, a preliminary survey was made of existing methods of egg production in Virginia. It was found that the bulk of Virginia eggs are sold from small farm flocks to retail country merchants, with no attention to quality. It was found further that many commercial poultrymen are making a distinct effort to maintain quality of eggs by frequent gathering and storing in basements or cellars when the available market recognizes quality.

The Virginia Division of Markets has long recognized the need for widespread marketing facilities for quality eggs and in 1928, in cooperation with the Agricultural Marketing Service of the U. S. Dept. of Agriculture, launched a Federal-State egg grading program (6). During the first year under this program slightly more than 14 million eggs were graded in an effort to create interest in the production of quality eggs. That this program has proved worthwhile is indicated by the fact that during the last fiscal year, 1939-40, more than 71 million eggs were graded, labeled and marketed through 40 Federal-State supervised grading stations within the State. Records from these sales show that, though representative of the best eggs produced at present, there is a difference of 20 percent in the number of top grade eggs received in hot weather as compared to cool weather receipts.

With the foregoing facts in mind, a cooperative project was initiated in July 1940 to study methods of cooling eggs and the resultant effect on the quality of eggs when marketed. The following cooperating agencies are directly charged with the responsibility for the conduct of the project: Division of Rural Electrification Research, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture; the Agricultural Engineering and Poultry Departments, Virginia Agricultural Experiment Station; and the Division of Markets, Virginia Department of Agriculture. At the outset the cooperators decided that the cooling of eggs on the farm alone would be a blind approach to the solution of the problem of maintaining quality and that the quality, however carefully preserved on the farm, would be almost immediately lost upon delivery to a market or grading station lacking cooling facilities. Consequently, the project was outlined to study methods of cooling eggs, both on the farm and at receiving stations.

Review of Previous Investigations

To gain some idea of how much the proper cooling of eggs might be relied upon to assist in providing the consumer with a high quality product, a survey was made of the work carried on by other investigators. For instance, it was realized that no matter how proper or efficient the cooling method might be, the final quality of the egg as consumed could not be made to exceed the initial quality of the egg when laid.

According to Almquist (2), experimental work has disclosed several facts which show that eggs are not "created equal" or, if they are, they do not long remain so. Initial quality and keeping quality may vary greatly from egg to egg but are found to vary to a relatively small extent in the eggs from the same hen. It appears, also, that even with perfectly consistent grading by candling, or by any other method, eggs originally all of one grade, because of the wide difference in their keeping powers, will be found distributed in part through several lower grades after storage or shipment.

It is evident then that frequent gathering and cooling of eggs will not eliminate or correct their inherent initial and keeping qualities. Further, it is plausible to believe that the results of cooling eggs from several flocks of hens, would not be identical and that the final quality of eggs, as consumed, could be appreciably improved by careful breeding and selection of hens which produce eggs of high initial and keeping quality.

The question then naturally arises as to whether or not the cooling of eggs can possibly assist in profitably maintaining the quality of eggs under present conditions. Montfort (7), Winton (12) and Black (4) state that there is just as much deterioration in three days when eggs are held at 98.6 degrees Fahrenheit as in 23 days when kept at 60.8 degrees Fahrenheit or in 65 days when the temperature is 44.6 degrees Fahrenheit. While this account shows vividly the effect of air temperature on egg deterioration it does not at the same time consider air moisture or relative humidity which other investigators have found to be an equally important factor. For instance, Jeffrey and Darago (5) found that interior egg quality, as expressed by height of the thick albumen, was not affected by relative humidity and that decline in interior egg quality was regulated by temperature. "At the same time, however, a high relative humidity tended to reduce the rate of evaporation of the egg content and also reduced the incidence of eggs with severly mottled shells. Results from their studies indicated definitely that low relative humidity causes shell mottling. Alp, Ashby and Card (3) of Illinois have shown that two shippers using wet burlap curtain coolers similar to those developed in California (9) and Oklahoma (10) increased the number of "extras" in eggs shipped from Illinois to New York by an average of 28 percent. This cooler with natural ventilation provides high humitity and medium temperatures by the evaporation of water from a wet curtain. They warn, however, that trouble from mold may develop if the cooler is used in a room without sufficient ventilation.

Thompson and Roberts (10) observed that 96.8 percent of the eggs stored in a wet burlap cooler and 97.2 percent of these stored in a mechanical refrigerator graded number one eggs after eight days of storage. These eggs were candled by a commercial egg grader.

Farm Cooler Tests

Since the burlap curtain cooler is of low initial cost and in some cases approaches very closely to the mechanical refrigerator as a device for conserving egg quality, it was given first consideration at the outset of the project. It was thought that a small electric fan might be incorporated into the burlap cooler, to provide a definite movement of air through the wet curtain, improve the performance of the cooler and eliminate the development of molds. Consequently, such a cooler was constructed (Fig. I), and tested, with and without a fan, in a room where the temperature and humidity could be controlled as needed. A series of tests were conducted in each case with temperatures around the cooler ranging from 60 to 90 degrees Fahrenheit and with relative humidities ranging from 30 to 90 percent. Observations for each test were made throughout a 15-minute period, though the cooler was actually operated at the prescribed conditions for about an hour prior to each test to make sure of atmospheric equilibrium throughout.

Water in the upper cooler pan was kept at a constant level for all tests, as determined by a hook-gauge, and the temperature of this water was maintained at 60 degrees Fahrenheit.

Comparative results of these tests are shown in Fig. 2 by the temperature and humidity curves for the cooler as operated with and without the eight-inch fan. Wet and dry-bulb temperatures were observed at two points, top and bottom, within the cooler by means of a motor aspirated psychrometer. These readings were applied to standard tables, corrected for atmospheric pressure, and the observations thus obtained were averaged to provide the values as shown by the curves. Temperatures and humidities were obtained at six points within the control room in a manner similar to the above, using a hand aspirated psychrometer. Ten thermocouples were located at as many points, both within and without the cooler, as a further check on dry-bulb psychrometer readings.

While these curves are plotted against an ambient temperature of 80 degrees Fahrenheit, which is about the summer mean for Virginia, they are representative of all other tests. They show clearly the effects of the use of an eight-inch fan on the burlap curtain cooler, so far as temperature and humidity are concerned.

Air flow through the cooler, when used without the fan, was so slow that it could not be measured by any of the instruments available for the tests. Smoke was used, however, to determine the direction of flow, which was found to be from top to bottom of the cooler. This flow was most rapid when the ambient relative humidity was low and the flow decreased as this humidity increased until at a point of 80 percent or above there was no perceptible air flow in either direction. The further use of smoke indicated that, without a fan on the cooler, there was little or no movement of air directly through the wet curtain at any time.

The bottom of the cooler was made air-tight when the fan was used so that the entering air was drawn directly through the wet curtain and exhausted through the top of the cooler. This air flow was fairly constant under all operating conditions and provided the cooler with about four air changes per minute as determined by a vane anemometer. Other coolers (Fig. 3) of the evaporation type, will be tested in the control room as time permits.

Conclusions from the tests outlined above led to the use of the small eight-inch electric fan on the burlap curtain cooler in all egg cooling tests to be outlined later. Such a cooler can be constructed for about $25.00 including the fan, lumber, sheet metal, hardware and labor. When eggs are shipped twice each week, as they should be, this cooler has a weekly capacity of eight 30-dozen cases, allowing space for cases to be precooled, and trays where eggs are initially stored for quick removal of heat. Plans for construction of this cooler have been prepared and will be available upon request, though certain minor changes are to be made in the cooler for experimental purposes.

Sufficient data are now available on a second experimental egg cooler to warrant a brief discussion. This second cooler is similar in construction to a wet-storage type milk cooler. It consists of a cabinet enclosing a

coil (Fig. 4) made from 60 feet of three-eighths inch copper tubing. The cabinet is 38 inches square and 32 inches deep, inside, accommodating four cases and two trays. It is insulated with one thickness of three-fourths inch asphalt-impregnated building board, known commercially as "Firtex." This assembly has been designated as a coil cooler (Fig. 5) and is designed as an auxiliary to a large farm refrigerator or milk cooler, deriving its refrigeration from same. During egg cooling tests conducted last summer, it was operated in conjunction with a four-can wet storage milk cooler. A small pump was connected to circulate refrigerated water from the milk cooler through the copper coil in the egg cooler.

Temperature regulation within the egg cooler was provided by a converted electric brooder thermostat which was connected in series with the motor on the pump. To provide better humidity conditions a shallow sheet metal pan was built to cover the entire floor of the cabinet. The bottom of the pan was covered with one inch of mineral wool and a false slatted floor was placed in the pan to provide a support for egg cases. The pan was partially filled with two gallons of water, a portion of which was taken up in saturating the mineral wool. The humidifying effect of this arrangement was disclosed from egg cooling tests through a period of one month with the thermostat adjusted to hold a temperature of 58 to 60 degrees Fahrenheit. Throughout this period the relative humidity remained between 70 and 80 percent, regardless of surrounding air conditions. Observations showed that, though water condensed on the cooling coil, it merely collected to later drop into the water pan, providing a continuous cycle of humidification. A smaller cooler of this type is now being designed to operate with a domestic refrigerator to fill the needs of the owners of small farm flocks.

Egg Cooling Tests

To determine the possibilities for the burlap and coil coolers in practical use, a series of tests were conducted during the summer of 1940 from July 16 to September 18. Eggs for these tests were obtained from a trap-nested flock of White Leghorn pullets at the Experiment Station. The eggs were gathered twice daily, at 11:00 A.M. and 4:30 P.M., and graded by weight (Fig. 6). They were then divided into lots, averaging about four dozen eggs each, with the variation in egg weights distributed uniformly throughout all lots. Each lot was numbered and given a predetermined treatment by storing in one of the coolers or at room conditions. New cases, flats and fillers were used throughout these tests. As a rule, eggs were shipped twice each week from Blacksburg, Virginia by railway express to a Federal-State supervised grading station in Washington, D. C., a distance of 258 miles. All eggs were candled and graded in Washington by a certified grader and a record kept by lots of the number of eggs in each grade and the resultant selling price. Slightly over 10,000 eggs were handled as described above during the course of the tests.

Time will not allow a more detailed description and discussion of these tests. The test season was cool and humid as compared to normal Virginia conditions. The following observations have been made from an analysis of the records:

1. From July 16 to August 22 the mean room temperature and relative humidity were 77 degrees Fahrenheit and 73 percent, respectively, while the same factors in the burlap cooler were 69 degrees Fahrenheit and 94 percent, respectively. Eggs stored in the room and shipped twice each week during this time graded 30.5 percent extras while similar eggs from the burlap cooler graded 56.3 percent extras. Thus, a net gain of 32 cents per case resulted (about one cent per dozen). The energy cost for operating the cooler amounted to five cents per case with electricity at three cents per kilowatt hour. It was also observed that precooling eggs for 45 minutes in a wire basket before storing them in cases in the burlap cooler resulted in an increase of 2.3 percent in the number of extras as compared with no precooling.

2. From August 22 to September 18 the mean room temperature and relative humidity were 74 degrees Fahrenheit and 67 percent, respectively, while the same factors in the burlap cooler were 67 degrees Fahrenheit and 89 percent, respectively, and in the coil cooler were 60 degrees Fahrenheit and 75 percent, respectively. Eggs stored in the room and shipped twice each week during this time graded 22.5 percent extras. Eggs from the burlap cooler graded 51.7 percent extras and those from the coil cooler graded 60.4 percent extras. Thus a net gain of 65 cents per case (about 2.2 cents per dozen) resulted from the use of the burlap cooler and 78 cents per case (about 2.6 cents per dozen) from the use of the coil cooler. The energy cost for operating the coolers amounted to five cents per case for the burlap cooler and 15 cents per case for the coil cooler, with electricity at three cents per kilowatt hour.

3. One lot of eggs was held for 11 days before shipping; at the time of shipping there were candled and graded by a certified grader at Blacksburg. These eggs were again candled and graded in Washington two days later to observe the effects of cooling on loss in egg quality en route to market. Eggs held at room conditions graded 16.7 percent extras in Blacksburg and 1.1 percent extras in Washington, which represents a shipping loss of 93.4 percent in extras. Eggs held in the burlap cooler graded 39.7 percent extras in Blacksburg and 38.6 percent extras in Washington, which represents a shipping loss of only 2.8 percent in extras. Eggs held in the coil cooler graded 61 percent extras in Blacksburg and 50.3 percent extras in Washington, which represents a shipping loss of 17.5 percent in extras. The resultant monetary loss per case in shipment amounted to 80 cents for eggs held at room conditions, 21 cents for eggs from the burlap cooler, and 50 cents for eggs from the coil cooler.

4. On four occasions eggs were gathered at 11:00 A.M. and divided into two lots uniform in egg weights. One lot was packed in a case which had been held at room conditions and the other lot was packed in a case which had been stored for three days in the burlap cooler. Both lots were then shipped directly to Washington where they were graded the next day. Eggs from the case held at room conditions graded 57.6 percent extras and eggs from theprecooled case graded 72.0 percent extras. This represented a net gain of 20 cents per case by shipping in precooled cases. Later tests were conducted to determine the moisture content of cases, containing flats and fillers, under room and burlap cooler conditions. These tests showed that the

equilibrium moisture content of cases under room conditions was 8.7 percent. Seven days were required in the cooler to reach the equilibrium moisture content of 15 percent in the cases. Hence, it was found that each case in the burlap cooler can store six-tenths of a pound of water to be liberated later in providing moist air around eggs en route to market.

5. Investigators mentioned previously have found conclusively that temperature and humidity effect the loss in egg quality tremendously. It so happened that on one occasion during tests conducted last summer, the decided effect of relative humidity on egg quality was particularly noticeable as shown in figure 7. These observations indicate that with a temperature of 74 degrees Fahrenheit, the critical point of relative humidity between high and low quality eggs lies between 65 and 75 percent.

6. The effect of the duration of the holding period on egg quality prior to shipment was also observed from last summer's tests. The curves in Fig. 8 show clearly that there is a definite loss in egg quality, day by day, as the holding period increases.

7. All eggs handled during the summer's tests were free from mold when graded in Washington except on one occasion. An accidental leak developed in the upper pan of the burlap cooler causing the flats, fillers and eggs in one case to become water-soaked. Several lots of eggs in this case were quite moldy when graded and the entire shipment was discarded from final analysis of the records.

Cooling Facilities for Receiving Stations

Studies of cooling facilities at egg grading stations in Virginia during the summer of 1940 were only preliminary because of limited personnel. Prior to 1940 there were seven grading stations with cooling facilities which were largely a result of an educational program sponsored by the Division of Markets. Two of these were equipped with insulated rooms, cooled by ice at a cost of about 30 dollars per month. The other five were equipped with insulated rooms cooled by the evaporation of water similar to that developed in California by Perry and Long (8).

One of the ice-cooled rooms was converted during the summer of 1939 for cooling by evaporation. Observations were made in this room during the summer of 1940. It had a double floor with building paper between the two floors, and the walls and ceiling were double, enclosing a four-inch thickness of mineral wool. A standard refrigerator door was used at the entrance to the room, an excelsior screen three inches thick was located in one end wall, and a 12-inch exhaust fan located in the opposing end wall near the door.

The operating cost of the room averaged slightly over three dollars per month including electricity and water. Though the cooling system was quite effective, providing temperatures from four to fifteen degrees Fahrenheit below outside temperatures and relative humidities from 35 to 50 percent higher than outside observations pointed the way to improvements in construction and effectiveness. For instance, every time the door to the

room was opened there was an in-rush of hot air because of the location of the fan. The resistance to air flow through the open door was so much less than through the wet excelsior screen that the room was well tempered with hot air each time the door was opened. This condition was corrected in subsequent installations (Fig. 9) by locating the fan to force air through the evaporative screen and into the room.

Continual leakage of water from the old excelsior screens and the fact that it is impossible to fill the screen uniformly with excelsior has led to the development of a new screen, simpler in construction, lower in first cost and of greater accessibility. Tests recently completed in the laboratory at Blacksburg show that for optimum effectiveness, rooms of this type should be provided with from one to two air changes per minute, which is about double that provided in the first installation observed. To eliminate draft, uncomfortable to occupants of the cooling room, the velocity of air flow through the wet screen should not exceed 125 to 175 feet per minute.

As a result of foregoing tests and observations, the installation cost of such rooms has been reduced by about one-third. Detailed plans for the construction of an egg cooling room of this type are now available upon request to the Virginia Polytechnic Institute, Blacksburg, Virginia.

Summary

Eggs held in experimental coolers prior to shipment twice a week from the farm have shown net increases in selling price of from 32 to 78 cents per case over similar eggs furnished no cooling. Precooling eggs for 45 minutes in a wire basket before storing them in cases in the coolers showed an increase of 2.3 percent in the number of extras as compared with no precooling.

Loss in egg quality during shipment amounted to 80 cents per case for eggs held at room conditions and from 21 to 50 cents per case for eggs held in the coolers. Fresh laid eggs shipped in precooled cases from the coolers brought a net selling price of 20 cents per case more than those received for similar eggs shipped in cases not precooled. Cases, containing flats and fillers, will absorb six-tenths of a pound of water while in the coolers seven days and this water is later available to provide moist air around eggs en route to market.

Indications are that with a mean ambient temperature of 74 degrees F. the critical point of ambient relative humidity between high and low quality eggs lies between 65 and 75 percent. There is a rather constant loss in egg quality from day to day during the holding period, regardless of treatment, though eggs held in the coolers were of a consistent higher quality than eggs held under room conditions.

ACKNOWLEDGMENT

The authors take great pleasure in acknowledging the faithful assistance of the following in conducting the project:

J. B. Elrod, A. B. Stephenson, C. E. Seitz and Harry L. Moore of the Virginia Agricultural Experiment Station; and Harry L. Garver of the Bureau of Agric. Chem. & Engr., U. S. Dept. of Agriculture. Others have assisted in various capacities to a somewhat lesser extent, for which the authors are deeply grateful.

Citations

1. Agricultural Statistics, 1940. U. S. Department of Agriculture, p. 477. For sale by Supt. of Documents, 75 cents.

2. Almquist, H. J. - Relation of the Candling Appearance of Eggs to Their Quality. California Agricultural Experiment Station, Berleley, Bul. 561, Nov. 1933.

3. Alp, H. H., Ashby, R. C. and Card, L. E. - Studies of the Market Quality of Eggs from 109 Farms in Southeastern Illinois. Illinois Agricultural Experiment Station, Bul. 441, Apr. 1938.

4. Black, Leslie M. - Hints to Poultrymen - Preserving Egg Quality on the Farm. New Jersey Agricultural Experiment Station, Vol. 25, No. 5, June - July, 1938.

5. Jeffrey, F. P. and Darago, V. - Effect of High Humidity on Egg Quality During Short Holding Periods. New Jersey Agricultural Experiment Station, Bul. 682, Oct. 1940.

6. Meek, J. H. - Special Report on the Federal-State Egg Grading Service - For Fiscal Year 1939 - 1940. Virginia Division of Markets, Richmond, mimeographed.

7. Montfort, P. T. - Report of Year's Progress in the Refrigeration of Eggs on the Farm. Texas A. & M. College, Report of farm Electrification Short Course, Nov. 1931.

8. Perry, R. L. and Long, J. D. - Methods of Improving Summer Living Comfort. California Agricultural Experiment Station, Agric. Engr. Infor. Series, No. 7.

9. Ruden, W. L. - Performance Tests on Evaporation Type Coolers, Agricultural Engineering, Vol. 10, No. 11, Nov. 1929.

10. Thompson, R. B. and Roberts, C. A. - A Homemade Egg-Cooler for Farm Use. Oklahoma Agricultural Experiment Station, Bul. 240, Apr. 1940.

11. Virginia Farm Statistics, 1937-1938. Virginia Cooperative Crop Reporting Service, Richmond, 1939.

12. Winton, Berley - Improve Missouri Eggs, University of Missouri, Extension Circular 298, Dec. 1932.

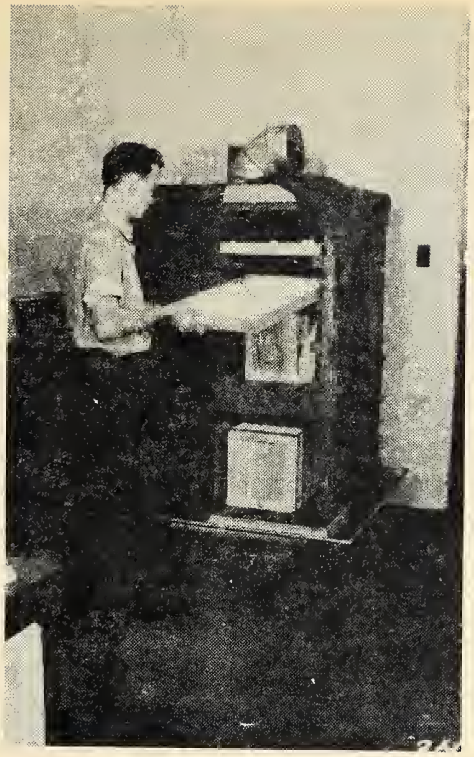


Figure 1

Burlap Egg Cooler

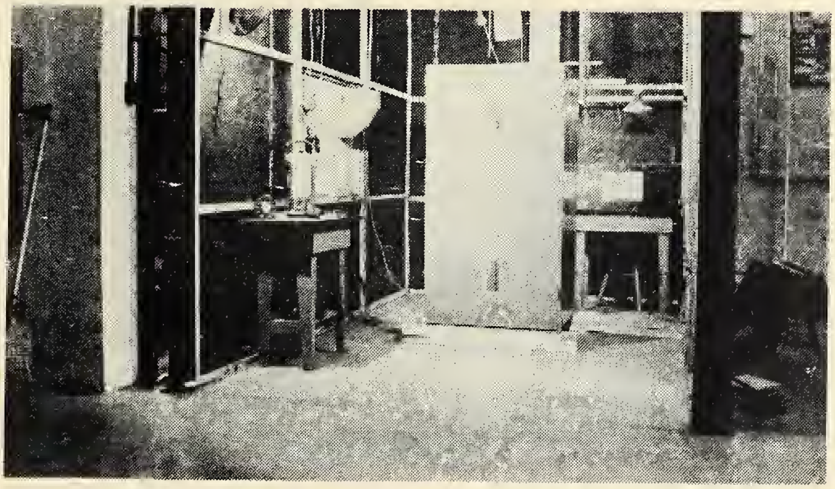
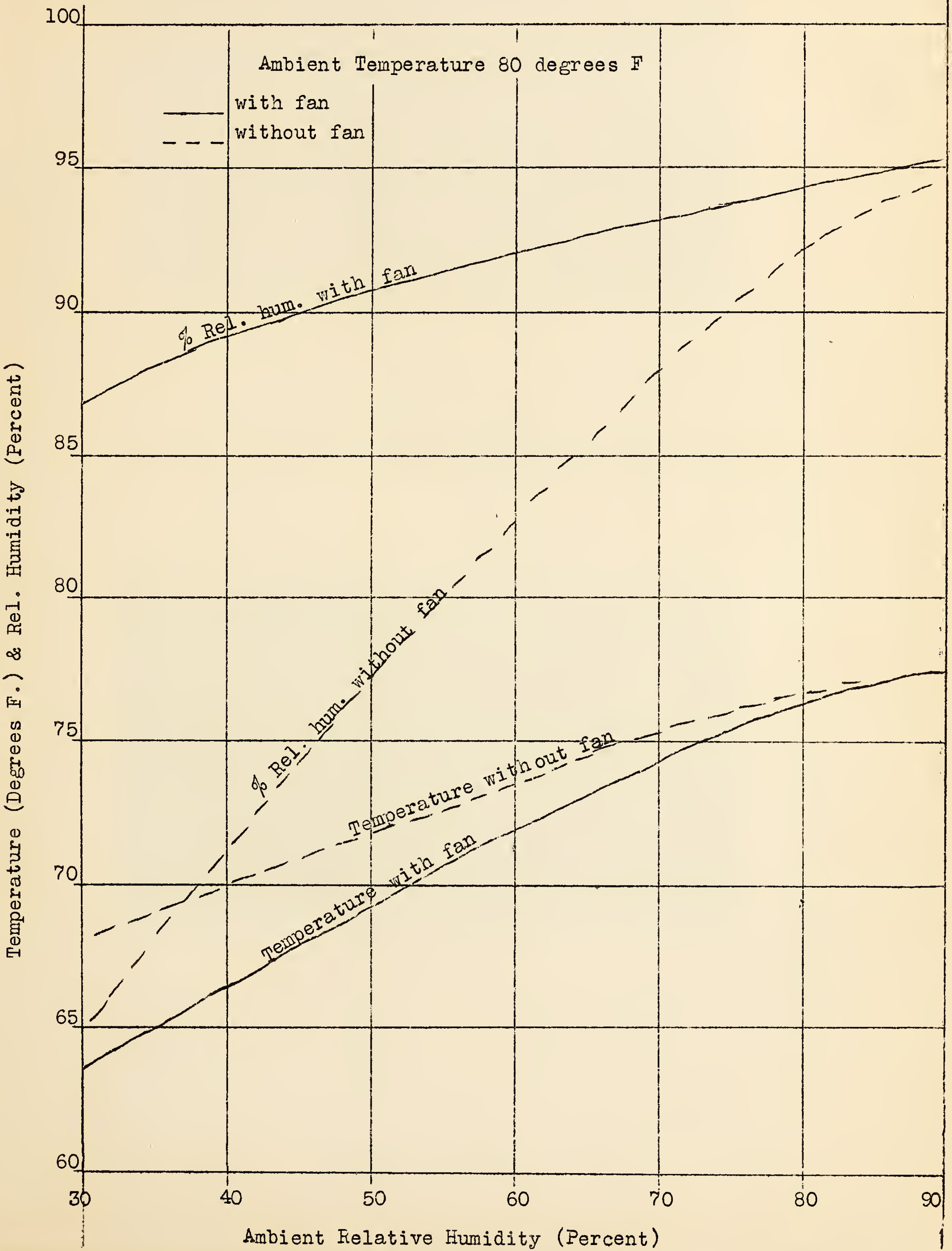


Figure 3

Evaporation-Type Cooler

Fig. 2

Curves Show Mean Interior Temperature and Humidity of Burlap
Egg Cooler with and without Fan in Relation to
Ambient Relative Humidity



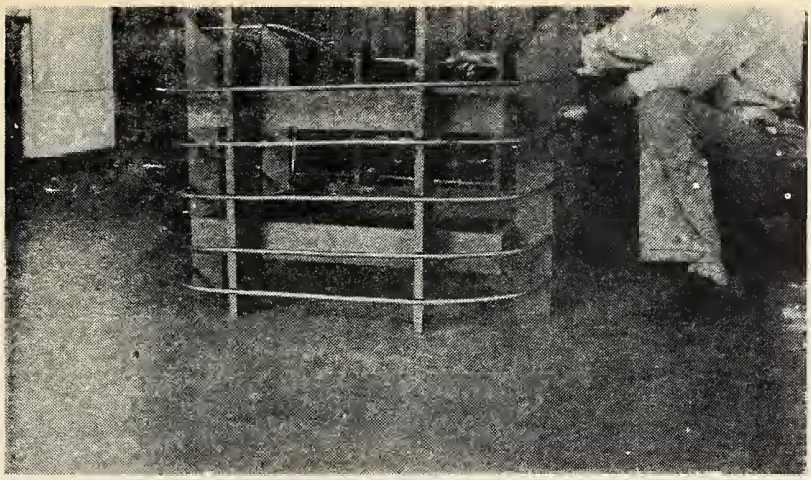


Figure 4

Coil-Type Cooler
Showing the Cooling Coils

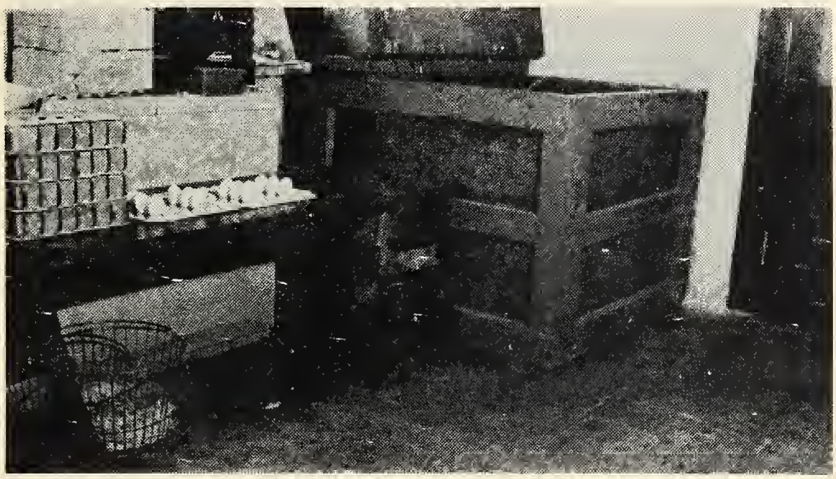


Figure 5

Coil-Type Cooler

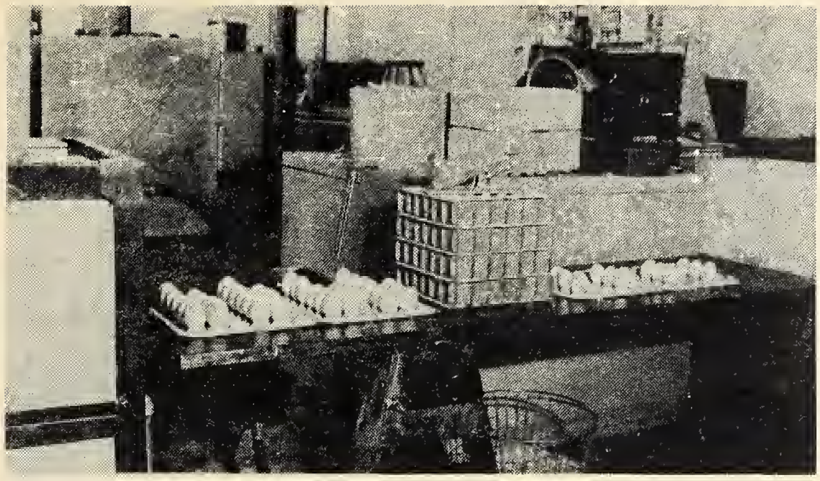


Figure 6

Eggs Graded by Weight

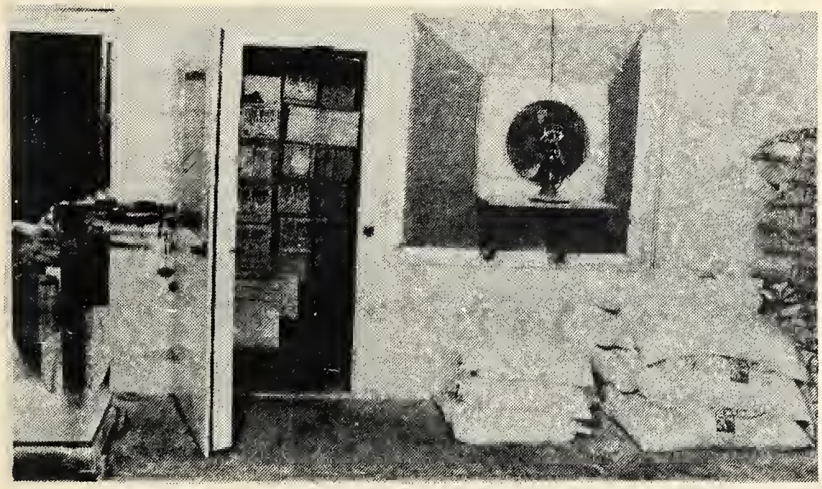
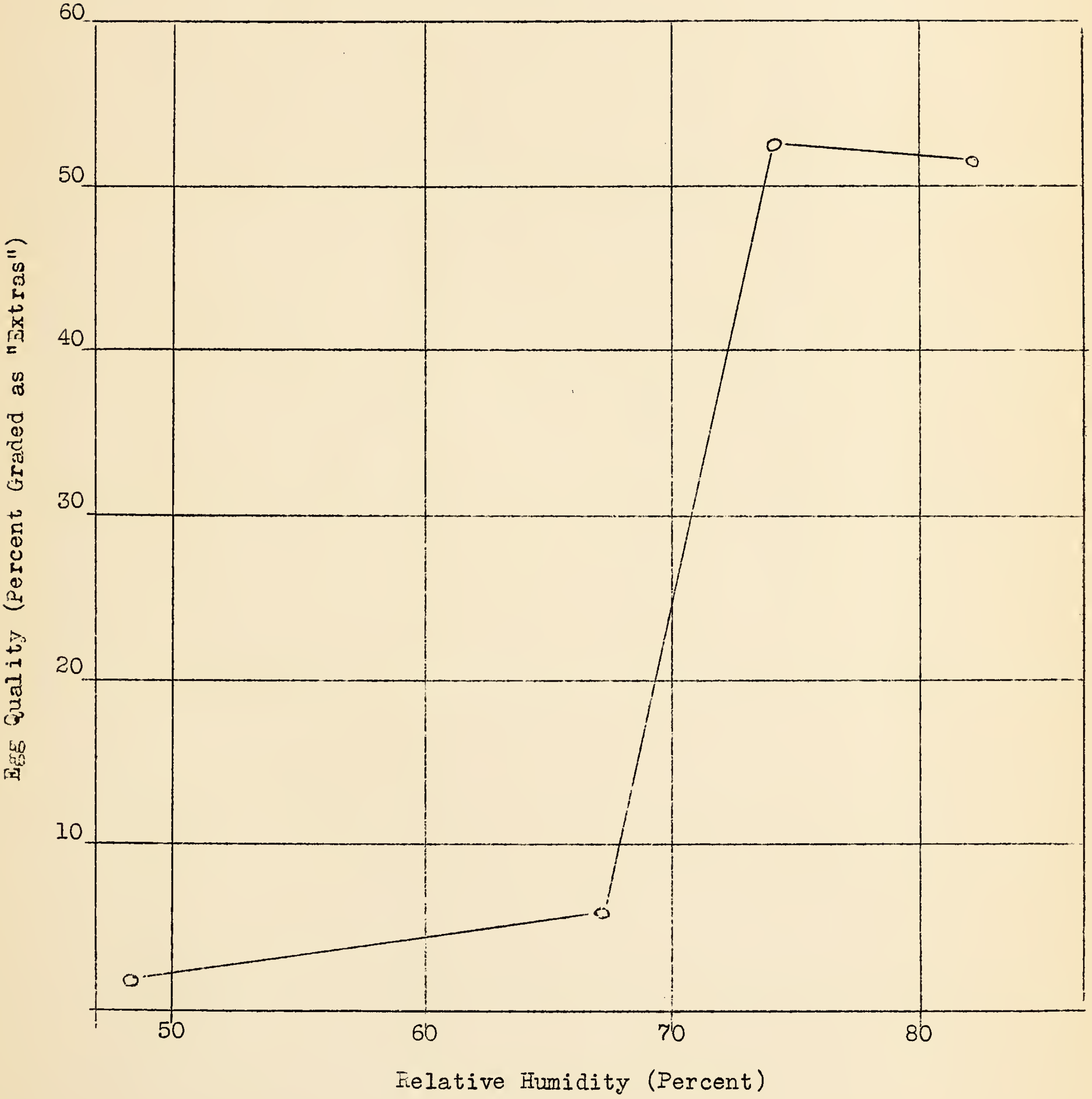


Figure 9

Cooling Room at Receiving Station
Showing Location of Fan

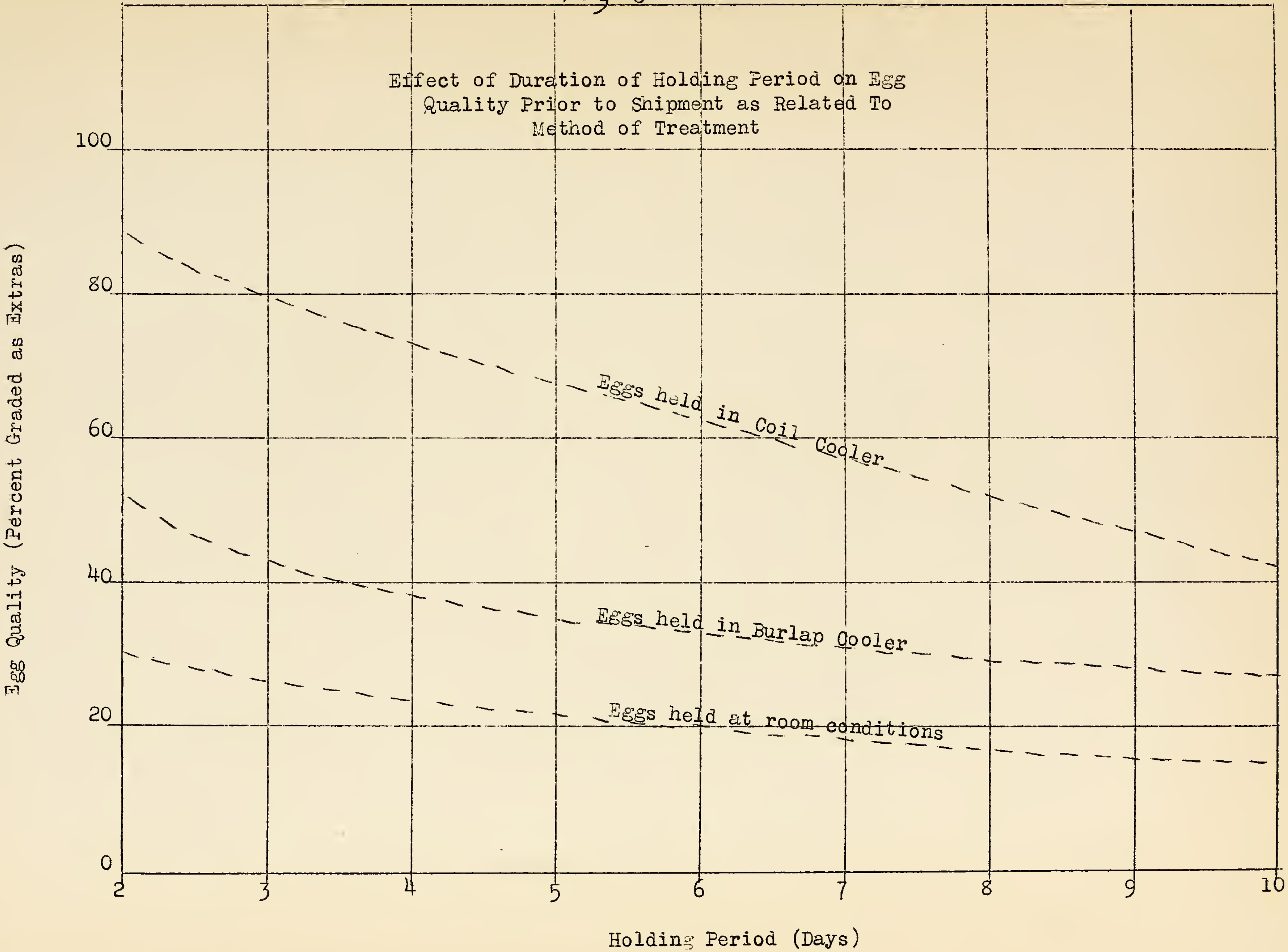
Fig. 7

Effect of Relative Humidity on Egg Quality



Mean Air Temperature: 74 degrees F.

Fig. 8



Effect of Duration of Holding Period on Egg Quality Prior to Shipment as Related To Method of Treatment